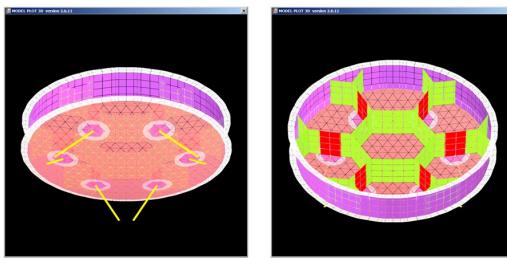


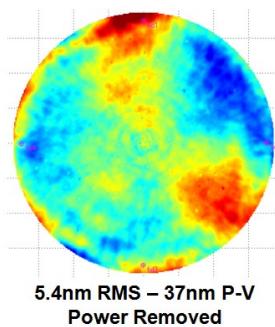
## Accomplishments (cont.)

*Support System:* Arnold Mirror Modeler has added support systems (hexapod, axial, lateral, etc.),



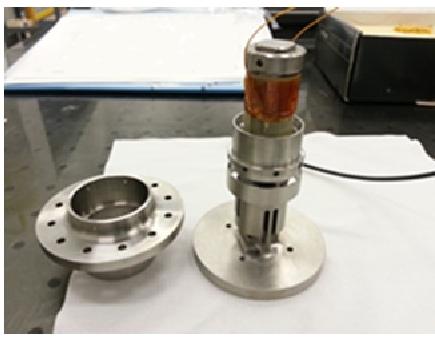
interface pads (number, size, etc.) and launch support systems. Capability allows analysis of internal stress for candidate Pre-Phase-A point designs as a function of launch environment.

*Figure Error:* AMTD partner Exelis polished the 40 cm mirror to a zero-gravity figure of 5.5 nm rms.



MSFC tested the mirror from 250 to 300K and found insignificant (smaller than 4 nm rms) thermal deformation.

*Segment to Segment Gap Phasing:* Partner Exelis

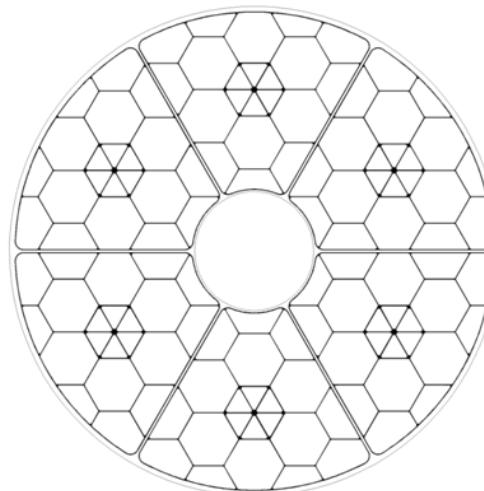


fabricated and tested a flight traceable rigid-body fine-motion actuator to phase segments that has half the mass and 10X better resolution than the JWST actuators.

## Phase II Awarded

1/3 Subscale of a 4m mirror, a 1.5m Pathfinder mirror designed using same processes and techniques developed under Phase I along with lessons learned improvements.

Pathfinder will be an on-axis, stacked core mirror like the Phase I Demo mirror. 18 core segments will be fabricated and co-fused with the face sheets. Pocketmilled face sheets have been eliminated due to system performance trade.



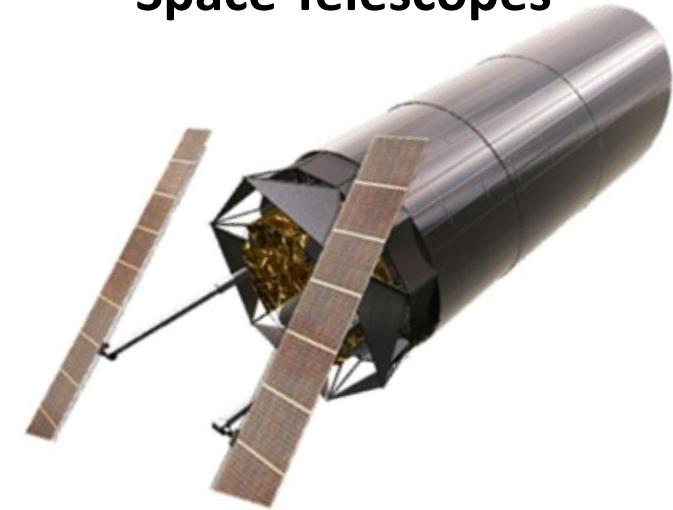
### Science Advisory Team:

Dr. Marc Postman, STScI  
Dr Stuart Shaklan, JPL  
Dr. Olivier Guyon, UoA  
Dr. John Krist, JPL

### Systems Engineering Team

Dr. H. Philip Stahl, NASA  
Dr. W. Scott Smith, NASA  
Dr. Gary Mosier, NASA  
Al Ferland, Exelis  
William Arnold, DAI/Jacobs

# Advanced UVOIR Mirror Technology Development (AMTD) for Very Large Space Telescopes



AMTD is a multiyear effort to develop, demonstrate and mature critical technologies to TRL-6 by 2018 so that a viable flight mission can be proposed to the 2020 Decadal.



**EXELIS**



**JPL**



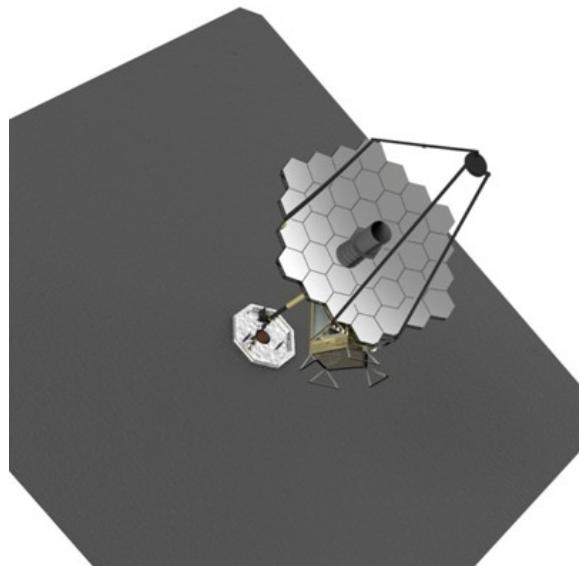
## Long Term Needs

ASTRO2010 Decadal stated that an advanced large-aperture ultraviolet, optical, near-infrared (UVOIR) telescope is required to enable the next generation of compelling astrophysics and exoplanet science; and, that present technology is not mature enough to affordably build and launch any potential UVOIR mission concept.



AMTD builds on the state of art (SOA) defined by over 30 years of monolithic & segmented ground & space-telescope mirror technology to mature six key technologies.

AMTD is deliberately pursuing multiple design paths to provide the science community with options to enable either large aperture monolithic or segmented mirrors with clear engineering metrics traceable to science requirements.



## Key Technology Development

AMTD uses a science-driven systems engineering approach to: 1) provide direct traceability between science requirements and engineering specifications and 2) mature those technologies required to enable the highest priority science AND result in a high-performance low-cost low-risk mission.

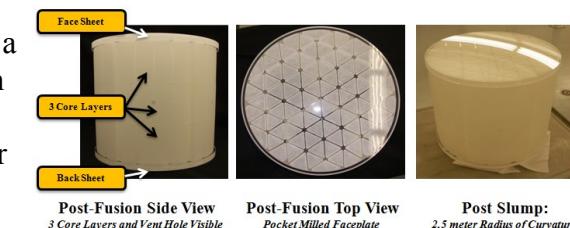
- **Large-Aperture, Low Areal Density, High Stiffness Mirror Substrates:** Both (4 to 8 m) monolithic and (8 to 16 m) segmented primary mirrors require larger, thicker, and stiffer substrates.
- **Support System:** Large-aperture mirrors require large support systems to ensure that they survive launch and deploy on orbit in a stress-free and undistorted shape.
- **Mid/High Spatial Frequency Figure Error:** Very smooth mirror is critical for producing high-quality point spread function (PSF) for high contrast imaging.
- **Segment to Segment Gap Phasing:** Segment phasing is critical for producing high-quality temporally-stable PSF.
- **Integrated Modeling:** On-orbit performance is driven by mechanical & thermal stability. Compliance cannot be 100% tested, but relies on modeling.

## Accomplishments

AMTD derived, from Science Requirements, Engineering Specifications for 4 to 8 m monolithic space mirrors and is working on segmented primary mirror specifications.

**Systems Engineering:** Engineering Specifications for 4 to 8 meter monolithic and segmented mirrors have been derived from the Science Requirements. The most stressing specification is that the mirror needs to be stable on the order of 10 picometers per 10 minutes. The second most stressing specification is that the mirror needs have a better than 6 nm rms surface figure error out to 60 cycles per aperture.

**Mirror Substrate:** Phase 1 demonstrated the ability to make a 40 cm thick mirror using the stacked core technique. Phase 2 will demonstrate lateral scalability to 1.5 meter.



**Integrated Modeling:** AMTD has developed a powerful set of tools that can quickly create monolithic or segmented mirror designs; integrate them into a support system; and analyze their static and dynamic mechanical and thermal performance. One analysis metric is the system Thermal Modulation Transfer Function, i.e. the rms wavefront error produced by a periodic thermal modulation.

